

What is claimed is:

1. An automatic intermediate frequency stabilization control apparatus comprising:

intermediate frequency signal producing means for producing an
5 intermediate frequency signal by combining light outputted from an FM
laser with light outputted from a local oscillating laser and performing
heterodyne detection with combined light, a difference between both
oscillation frequencies of the light outputs corresponding to the
intermediate frequency signal;

10 frequency discrimination means for discriminating in frequency
the intermediate frequency signal for automatic intermediate frequency
stabilization control;

detecting means for detecting a given state in which the
intermediate frequency signal is over in frequency than a specified
15 frequency; and

pulling control means for pulling the intermediate frequency
signal into a stable operation point for the automatic intermediate
frequency stabilization control when the detecting means detect the
given state.

20 2. The automatic intermediate frequency stabilization control
apparatus of claim 1, wherein the frequency discrimination means are a
frequency counter receiving the intermediate frequency signal and the
detecting means are overflow detecting means for outputting an
25 overflow signal when a count of the frequency counter reaches the
specified frequency.

30 3. The automatic intermediate frequency stabilization control
apparatus of claim 2, further comprising an electric coupler to make a
path of the intermediate frequency signal to a plurality of paths thereof
and a prescaler to divide the intermediate frequency signal received
through one of the paths up to an operation frequency of the frequency

counter,

wherein the overflow detecting means is configured so as to output the overflow signal in cases the intermediate frequency signal reaches a frequency indicative of an outside frequency band higher than a frequency band of electric circuitry constituents located before the prescaler, the frequency corresponding to the given frequency.

4. The automatic intermediate frequency stabilization control apparatus of claim 1, wherein the frequency discrimination means are a frequency counter receiving the intermediate frequency signal and holding a count corresponding to the given frequency when the intermediate frequency signal is over the given frequency and the detecting means detect the given state when the frequency counter holds the count thereof.

5. An automatic intermediate frequency stabilization control apparatus comprising:

intermediate frequency signal producing means for producing an intermediate frequency signal by combining light outputted from an FM laser with light outputted from a local oscillating laser and performing heterodyne detection with combined light, a difference between both oscillation frequencies of the light outputs corresponding to the intermediate frequency signal;

frequency discrimination means for discriminating in frequency the intermediate frequency signal for automatic intermediate frequency stabilization control;

determining means for determining a stable operation point for the automatic intermediate frequency stabilization control on the basis of a frequency of an output signal of the frequency discrimination means and primary and secondary differential values of the output signal frequency to either of bias current and temperature of at least one of the lasers; and

controlling means for pulling the intermediate frequency signal into the stable operation point determined by the determining means.

6. The automatic intermediate frequency stabilization control apparatus of claim 5, wherein the determining means is configured so as to determine, as the stable operation point, a point of frequency satisfying a condition that the output signal frequency of the frequency discrimination means is at a target frequency, the primary differential value is within a predetermined range, and the secondary differential value is approximately zero.

7. The automatic intermediate frequency stabilization control apparatus of claim 5, wherein the determining means is configured so as to determine, as the stable operation point, a point of frequency satisfying a condition that the output signal frequency of the frequency discrimination means is at a target frequency, the primary differential value is either positive or negative, and the secondary differential value is approximately zero.

8. The automatic intermediate frequency stabilization control apparatus of claim 5, wherein the determining means is configured so as to determine, as the stable operation point, a point of frequency satisfying a condition that the output signal frequency of the frequency discrimination means is at a target frequency, the primary differential value is either positive or negative within a predetermined range, and the secondary differential value is approximately zero within a predetermined range.

9. The automatic intermediate frequency stabilization control apparatus of claim 5, wherein the determining means is configured so as to determine, as the stable operation point, a point of frequency satisfying a condition that the output signal frequency of the frequency

discrimination means is at a target frequency and the primary differential value is either positive or negative within a predetermined range in a region where the secondary differential value is approximately zero within a predetermined range, the bias current or temperature being changed at random.

10. An automatic intermediate frequency stabilization control apparatus comprising:

intermediate frequency signal producing means for producing an intermediate frequency signal by combining light outputted from an FM laser with light outputted from a local oscillating laser and performing heterodyne detection with combined light, a difference between both oscillation frequencies of the light outputs corresponding to the intermediate frequency signal;

memorizing means for memorizing data of at least one of bias current and temperature of at least one of the FM laser and the local oscillating laser when a stabilized control state of the intermediate frequency signal continues for a certain time; and

restart control means for restart stabilized control of the intermediate frequency signal by controlling an oscillation signal of at least one of the FM laser and the local oscillating laser on the basis of at least the bias current and the temperature memorized in cases the intermediate frequency signal deviates from the stabilized control state.

11. The automatic intermediate frequency stabilization control apparatus of claim 10, wherein the stabilized control state of the intermediate frequency signal is a state in which a difference between the intermediate frequency and a target frequency is smaller than a given value.

12. The automatic intermediate frequency stabilization control apparatus of claim 11, further comprising detecting means for detecting

a given state in which the intermediate frequency signal is a value residing in an outside of a specified frequency region; and pulling control means for pulling the intermediate frequency signal into a stable operation point for the automatic intermediate frequency stabilization control when the detecting means detect the given state.

13. The automatic intermediate frequency stabilization control apparatus of claim 11, wherein the memorizing means is configured so as to update the memorized data at intervals during the stabilized control state of the intermediate frequency signal.

14. The automatic intermediate frequency stabilization control apparatus of claim 11, wherein the restart control means is configured so as to restart the stabilization control in cases the intermediate frequency signal deviates from the stabilized control state after continuation of the stabilized control state for a given period of time.

15. The automatic intermediate frequency stabilization control apparatus of claim 11, wherein the restart control means has means for stopping the control unless the stabilized control state is obtained even when an action to start the automatic stabilization control is repeated a predetermined number of times.

16. The automatic intermediate frequency stabilization control apparatus of claim 12, wherein the restart control means has means for searching a stable operation point for the automatic stabilization control by sweeping either the bias current or the temperature using, as a central value for the search, data of either the bias current or the temperature memorized in the memorizing means in cases the intermediate frequency signal deviates from the stabilized control state.

17. The automatic intermediate frequency stabilization control

apparatus of claim 12, wherein the restart control means has means for searching a stable operation point for the automatic stabilization control by sweeping either the bias current or the temperature using, as a central value for the search, data of either the bias current or the temperature memorized in the memorizing means unless a stabilized control state is found even when the automatic stabilization control is restarted.

18. The automatic intermediate frequency stabilization control apparatus of claim 12, wherein the restart control means has means for searching a stable operation point for the automatic stabilization control by sweeping either the bias current or the temperature using, as a central value for the search, data of either the bias current or the temperature memorized in the memorizing means unless the stabilized control state is found even when the stabilization control is restarted and means for stopping the automatic stabilization control unless the stabilized control state is realized even when the search of the stable operation point is repeated a predetermined number of times.

19. The automatic intermediate frequency stabilization control apparatus of claim 12, wherein the restart control means has means for repeating an action to restart the stabilization control up to a first predetermined number of times n_0 , means for searching a stable operation point for the automatic stabilization control by sweeping the bias current or the temperature using, as a central value for the search, data of either the bias current or the temperature memorized in the memorizing means unless the stabilized control state is obtained through repeating the automatic stabilization control, and means for stopping the automatic stabilization control unless the stabilized control state is obtained through repeating the search a second predetermined number of times " $n_1 - n_0$ " ($n_0 < n_1$).

20. The automatic intermediate frequency stabilization control apparatus of claim 12, wherein the restart control means has means for repeating an action to restart the stabilization control up to a first predetermined number of times n_0 , means for searching a stable operation point for the automatic stabilization control by sweeping the bias current or the temperature using, as a central value for the search, data of either the bias current or the temperature memorized in the memorizing means unless the stabilized control state is obtained through repeating the automatic stabilization control, and means for setting at least one of the bias current and the temperature to initial values unless the stabilized control state is obtained through repeating the search a second predetermined number of times " n_1-n_0 " ($n_0 < n_1$), mean for performing a waiting action during a certain period of time after the setting of the initial values, means for searching the stable operation point by sweeping the bias current or the temperature after the waiting, and means for stopping the automatic stabilization control unless the stabilized control state is obtained through repeating the search a third predetermined number of times " n_2-n_1 " ($n_0 < n_1 < n_2$).

21. An optical signal transmitter in which an automatic intermediate frequency stabilization control apparatus is incorporated, the automatic intermediate frequency stabilization control apparatus comprising:

intermediate frequency signal producing means for producing an intermediate frequency signal by combining light outputted from an FM laser with light outputted from a local oscillating laser and performing heterodyne detection with combined light, a difference between both oscillation frequencies of the light outputs corresponding to the intermediate frequency signal;

memorizing means for memorizing data of at least one of bias current and temperature of at least one of the FM laser and the local oscillating laser when a stabilized control state of the intermediate

frequency signal continues for a certain time; and

restart control means for restart stabilized control of the intermediate frequency signal by controlling an oscillation signal of at least one of the FM laser and the local oscillating laser on the basis of at least the bias current and the temperature memorized in cases the intermediate frequency signal deviates from the stabilized control state.

22. An optical signal receiver in which an automatic intermediate frequency stabilization control apparatus is incorporated, the automatic intermediate frequency stabilization control apparatus comprising:

intermediate frequency signal producing means for producing an intermediate frequency signal by combining light outputted from an FM laser with light outputted from a local oscillating laser and performing heterodyne detection with combined light, a difference between both oscillation frequencies of the light outputs corresponding to the intermediate frequency signal;

memorizing means for memorizing data of at least one of bias current and temperature of at least one of the FM laser and the local oscillating laser when a stabilized control state of the intermediate frequency signal continues for a certain time; and

restart control means for restart stabilized control of the intermediate frequency signal by controlling an oscillation signal of at least one of the FM laser and the local oscillating laser on the basis of at least the bias current and the temperature memorized in cases the intermediate frequency signal deviates from the stabilized control state.

23. An automatic intermediate frequency stabilization control apparatus comprising:

intermediate frequency signal producing means for producing an intermediate frequency signal by combining light outputted from an FM laser with light outputted from a local oscillating laser and performing

heterodyne detection with combined light, a difference between both oscillation frequencies of the light outputs corresponding to the intermediate frequency signal; and

control means for, in cases the intermediate frequency signal deviates from a stabilized control state thereof, setting to an initial value at least one of bias current and temperature of at least of the FM laser and the local oscillating laser, performing a waiting action for a certain period of time after setting the initial value, and searching a stable operation point for automatic stabilization control of the intermediate frequency signal by sweeping the bias current or the temperature after the waiting.

24. The automatic intermediate frequency stabilization control apparatus of claim 23, wherein the stabilized control state of the intermediate frequency signal is a state in which a difference between the intermediate frequency and a target frequency is smaller than a given value.

25. The automatic intermediate frequency stabilization control apparatus of claim 23, wherein the control means include means for setting at least one of the bias current and the temperature to initial values thereof, before searching the stable operation point, in cases the intermediate frequency signal deviates continuously from the stabilized control state for a certain period of time.

26. The automatic intermediate frequency stabilization control apparatus of claim 23, wherein the control means has means for setting at least one of the bias current and the temperature to initial values thereof, performing a waiting action of a certain period of time after the setting of the initial values, and searching a stable operation point by sweeping the bias current or the temperature after the waiting, in cases the intermediate frequency signal deviates continuously from a

stabilized control state for a certain period of time, and means for stopping the automatic stabilization control unless the stabilized control state is obtained even when the search is repeated a predetermined number of times.

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27. An optical signal transmitter in which an automatic intermediate frequency stabilization control apparatus is incorporated, the automatic intermediate frequency stabilization control apparatus comprising:

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intermediate frequency signal producing means for producing an intermediate frequency signal by combining light outputted from an FM laser with light outputted from a local oscillating laser and performing heterodyne detection with combined light, a difference between both oscillation frequencies of the light outputs corresponding to the intermediate frequency signal; and

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control means for, in cases the intermediate frequency signal deviates from a stabilized control state thereof, setting to an initial value at least one of bias current and temperature of at least of the FM laser and the local oscillating laser, performing a waiting action for a certain period of time after setting the initial value, and searching a stable operation point for automatic stabilization control of the intermediate frequency signal by sweeping the bias current or the temperature after the waiting.

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28. An optical signal receiver in which an automatic intermediate frequency stabilization control apparatus is incorporated, the automatic intermediate frequency stabilization control apparatus comprising:

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intermediate frequency signal producing means for producing an intermediate frequency signal by combining light outputted from an FM laser with light outputted from a local oscillating laser and performing heterodyne detection with combined light, a difference between both

oscillation frequencies of the light outputs corresponding to the intermediate frequency signal; and

control means for, in cases the intermediate frequency signal deviates from a stabilized control state thereof, setting to an initial value at least one of bias current and temperature of at least of the FM laser and the local oscillating laser, performing a waiting action for a certain period of time after setting the initial value, and searching a stable operation point for automatic stabilization control of the intermediate frequency signal by sweeping the bias current or the temperature after the waiting.

29. A method for controlling an intermediate frequency in a stabilized control state, comprising the steps of:

producing means for producing an intermediate frequency signal by combining light outputted from an FM laser with light outputted from a local oscillating laser and performing heterodyne detection with combined light, a difference between both oscillation frequencies of the light outputs corresponding to the intermediate frequency signal;

discriminating in frequency the intermediate frequency signal for automatic intermediate frequency stabilization control;

detecting a given state in which the intermediate frequency signal is over in frequency than a specified frequency; and

pulling the intermediate frequency signal into a stable operation point for the automatic intermediate frequency stabilization control when the detecting means detect the given state.

30. A method for controlling an intermediate frequency in a stabilized control state, comprising the steps of:

producing means for producing an intermediate frequency signal by combining light outputted from an FM laser with light outputted from a local oscillating laser and performing heterodyne detection with combined light, a difference between both oscillation frequencies of the

light outputs corresponding to the intermediate frequency signal; and

in cases the intermediate frequency signal deviates from a stabilized control state thereof, setting to an initial value at least one of bias current and temperature of at least of the FM laser and the local oscillating laser, performing a waiting action for a certain period of time after setting the initial value, and searching a stable operation point for automatic stabilization control of the intermediate frequency signal by sweeping the bias current or the temperature after the waiting.

31. A method for controlling an intermediate frequency in a stabilized control state, comprising the steps of:

producing means for producing an intermediate frequency signal by combining light outputted from an FM laser with light outputted from a local oscillating laser and performing heterodyne detection with combined light, a difference between both oscillation frequencies of the light outputs corresponding to the intermediate frequency signal; and

on the basis of memorized data of at least one of bias current and temperature of at least one of the FM laser and the local oscillating laser memorized when the stabilized control state of the intermediate frequency signal continues for a certain time, restarting stabilized control of the intermediate frequency signal by controlling an oscillation signal of at least one of the FM laser and the local oscillating laser on the basis of at least the bias current and the temperature in cases the intermediate frequency signal deviates from the stabilized control state.

32. The method of claim 31, wherein the stabilized control state of the intermediate frequency signal is a state in which a difference between the intermediate frequency and a target frequency is smaller than a given value.

33. The method of claim 32, further comprising the steps of detecting a given state in which the intermediate frequency signal is

over in frequency than a specified frequency; and pulling the intermediate frequency signal into a stable operation point for the automatic intermediate frequency stabilization control when the given state is detected.

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34. The method of claim 32, wherein the memorized data are updated at intervals during the stabilized control state of the intermediate frequency signal.

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35. The method of claim 32, wherein the automatic stabilization control is restarted in cases the intermediate frequency signal deviates from the stabilized control state after continuation of the stabilized control state for a given period of time.

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36. The method of claim 32, wherein the control is stopped unless the stabilized control state is obtained even when an action to start the automatic stabilization control is repeated a predetermined number of times.

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37. The method of claim 32, wherein a stable operation point for the automatic stabilization control is searched by sweeping either the bias current or the temperature using, as a central value for the search, data of either the bias current or the temperature memorized in cases the intermediate frequency signal deviates from the stabilized control state.

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38. The method of claim 32, wherein a stable operation point for the automatic stabilization control is searched by sweeping either the bias current or the temperature using, as a central value for the search, data of either the bias current or the temperature memorized unless the stable operation point is found even when the stabilization control is restarted.

39. The method of claim 32, wherein a stable operation point for the automatic stabilization control is searched by sweeping either the bias current or the temperature using, as a central value for the search, data of either the bias current or the temperature memorized unless the stable operation point is found even when the stabilization control is restarted and the automatic stabilization control is stopped even when the search of the stable operation point is repeated a predetermined number of times.

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